

REC'D 29 APR. 1913

ANS'D

CONNECTICUT

AGRICULTURAL EXPERIMENT STATION

NEW HAVEN, CONN.

BULLETIN 157, SEPT., 1907.

LEAD ARSENATE AND PARIS GREEN.

I. Their Chemical Composition. By John Phillips Street, M.S.

II. Directions for their Use as Insecticides.

By W. E. Britton, Ph.D.

CONTENTS.

	PAGE
Lead Arsenate.....	4
Analyses of Lead Arsenate	5
Home-made Lead Arsenate	7
Advantages in Using Lead Arsenate.....	7
Paris Green.....	8
Analyses of Paris Green.....	9
Application of Lead Arsenate and Paris Green.....	12
Formula for Lead Arsenate	12
Formula for Paris Green.....	13

The Bulletins of this Station are mailed free to citizens of Connecticut who apply for them, and to others as far as the editions permit.

CONNECTICUT AGRICULTURAL EXPERIMENT STATION.

OFFICERS AND STAFF.

BOARD OF CONTROL.

His Excellency, ROLLIN S. WOODRUFF, <i>Ex officio</i> , President.	
PROF. H. W. CONN	Middletown.
PROF. W. H. BREWER, <i>Secretary</i>	New Haven.
B. W. COLLINS	Meriden.
CHARLES M. JARVIS	Berlin.
EDWIN HOYT	New Canaan.
J. H. WEBB	Hamden.
E. H. JENKINS, <i>Director and Treasurer</i>	New Haven.

STATION STAFF.

Chemists.

Analytical Laboratory.

JOHN P. STREET, M.S., *Chemist in Charge.*

E. MONROE BAILEY, M.S. KATE G. BARBER, PH.D., *Microscopist.*

Laboratory for the Study of Proteids.

T. B. OSBORNE, PH.D., *Chemist in Charge.* C. A. BRAUTLECHT, PH.B.

Botanist.

G. P. CLINTON, S.D.

Entomologist.

W. E. BRITTON, PH.D.

Assistant in Entomology.

B. H. WALDEN, B.AGR.

Forester.

AUSTIN F. HAWES, M.F.

Agronomist.

EDWARD M. EAST, PH.D.

Stenographers and Clerks.

MISS V. E. COLE.

MISS L. M. BRAUTLECHT.

MISS E. B. WHITTLESEY.

In charge of Buildings and Grounds.

WILLIAM VEITCH.

Laboratory Helper.

HUGO LANGE.

Sampling Agent.

V. L. CHURCHILL, New Haven.

LEAD ARSENATE AND PARIS GREEN.

I. THEIR CHEMICAL COMPOSITION.

BY JOHN PHILLIPS STREET.*

The constantly increasing use of insecticides in various spraying mixtures makes the effectiveness and the cheapness of the poisons used a matter of considerable practical importance. Paris green has been more commonly used for many years than any other arsenical insecticide, and has proved very effective. There is, however, a certain serious objection to its use; the partial solubility in water of the arsenious oxid, which frequently causes damage to foliage. For this reason entomologists have sought a different poison, which would be effective against insects, harmless to plants, and economical for the farmer to use. Lead arsenate seems to meet these requirements, and possesses a still further advantage over Paris green in that its mechanical condition keeps it longer in suspension in the spraying mixture. There are a number of brands of this material on the market, varying greatly in appearance and consistency, and it was considered advisable to make a somewhat extended chemical examination of them to determine their relative value. As the various brands of Paris green on sale in this State had never been analysed at this Station, they also have been included in this examination.

METHODS OF ANALYSIS.

In the analysis of lead arsenate the method proposed by Haywood† has been followed in all particulars, and has proved very satisfactory. With Paris green the same methods as used by the writer‡ in a similar examination at the New Jersey Station have

* The analyses of Paris green have been made by Messrs. E. M. Bailey and E. J. Shanley; those of lead arsenate by the writer.

† U. S. Dept. of Agl., Bur. of Chem., Bull. 105, 165.

‡ New Jersey Expt. Station, Bull. 195.

been followed. In addition, however, a test of the water-solubility of the arsenious oxid was made by the official A. O. A. C. method,* treating the green with distilled water for ten days.

LEAD ARSENATE.

Ten of the eleven samples analysed were taken from the museum stock of Dr. Britton, the State entomologist, but were recently acquired and were believed to be representative; the duplicate sample of Swift's arsenate was bought in the open market. The samples were received in containers of various sizes and material, from a one-pound glass jar to a fourteen pound wooden bucket. The material itself showed striking differences in consistency. Disparene settled out completely, leaving a supernatant liquid filling from one-fourth to one-third of the vessel; the Target brand and Swift's also showed some separated liquid, while the others were more of the consistency of putty and quite homogeneous.

The samples analysed were as follows:

19210. Eagle Brand. Adler Color & Chemical Co., New York.

19212. Target Brand. American Horticultural Distributing Co., Martinsburg, W. Va.

19211. Disparene. The Bowker Co., Boston, Mass.

19216. Star Brand. Fred. L. Lavanburg, New York.

19215. Anchor Brand. Leggett & Bro., New York.

19213. Swift's Arsenate. Merrimac Chemical Co., Boston, Mass.

18703. Duplicate of No. **19213**, purchased in market.

19643. Arsenate of Lead. Monmouth Chemical Works, Shrewsbury, N. J.

19357. Arsenate of Lead. The Powers-Weightman-Rosengarten Co., Philadelphia, Pa.

19358. Aiboneta. Schoonmaker & Son, Cedar Hill-on-Hudson, N. Y.

19209. Arsenate of Lead. The Vreeland Chemical Co., New York.

* U. S. Dept. of Agl., Bur. of Chem., Circ. 10, 3.

ANALYSES OF ARSENATE OF LEAD.

Station No.	Brand.	Original Material.						Water-Free.		
		Water.	Arsenic Oxide (As ₂ O ₃).	Lead Oxide (PbO).	Soluble Impurities (other than As ₂ O ₃ and PbO).	Insoluble Impurities (by difference).	Soluble Arsenic Oxide.	Arsenic Oxide (As ₂ O ₃).	Lead Oxide (PbO).	Total Impurities.
19210	Eagle	54.55	14.89	28.46	0.32	1.78	0.46	32.76	62.62	4.62
19212	Target	50.30	12.30	34.03	2.73	0.64	1.31	24.75	68.47	6.78
19211	Disparene	46.47	13.87	35.11	4.34	0.21	0.39	25.91	65.59	8.50
19216	Star	50.57	12.64	35.63	0.47	0.69	0.51	25.57	72.08	2.35
19215	Anchor	35.59	17.11	44.05	2.02	1.23	0.86	26.56	68.39	5.05
19213	Swift's	49.95	14.91	33.08	0.80	1.26	0.57	29.79	66.09	4.12
18703	"	48.40	15.19	33.78	0.88	1.75	0.30	29.44	65.47	5.09
19643	Monmouth	58.44	11.29	25.59	1.41	3.27	0.50	27.17	61.57	11.26
19357	Powers-Weightman	51.79	11.42	33.70	2.69	0.40	0.22	23.69	69.90	6.41
19358	Aiboneta	41.95	11.72	37.90	7.94	0.49	0.42	20.19	65.29	14.52
19209	Vreeland	33.65	21.91	41.44	0.74	2.26	0.86	33.02	62.46	4.52

RESULTS OF ANALYSES.

The analyses show lead arsenate to be far from a uniform material; the arsenic oxide ranges from 11.29 to 21.91 per cent., and the lead oxide from 25.59 to 44.05 per cent. The soluble arsenic oxide was low in all cases, ranging from 0.22 to 1.31 per cent., and this after a treatment for ten days. No soluble lead oxide was found in any of the samples. The nature of the impurities was not determined in any case; **19210**, **19358**, **19643** and **19357**, however, showed traces of nitrates. The impurities were not high except in three samples, **19211**, **19643** and **19358**; neither Disparene nor Aiboneta was sold as pure lead arsenate and therefore cannot be considered adulterated; the Monmouth sample, however, was sold as a pure material; in addition to its high content of impurities, it also contains the lowest percentages of both arsenic and lead oxids.

Lead arsenate is usually prepared by the action of lead acetate on disodium arsenate; some manufacturers, however, substitute lead nitrate for the acetate. Smith* has shown that the commercial grades of sodium arsenate and lead acetate and nitrate vary considerably. He found the lead oxide in lead acetate varied from 58.81 to 66.80 per cent., and in lead nitrate from 66.37 to

* Agr. Massachusetts, 1897, 357-369.

68.37 per cent.; while in sodium arsenate the arsenic oxid varied from 36.77 to 47.80 per cent. The calculation of the theoretical composition of commercial lead arsenate is, therefore, attended with some difficulty. Haywood,* however, has shown that, with pure chemicals, where lead acetate is used the theoretical composition should be 74.40 per cent. lead oxide and 25.60 per cent. arsenic oxide; and where lead nitrate is used, 64.26 and 33.15 per cent., respectively. The methods used in the above analyses give results very close to theory where the lead arsenate is prepared from lead nitrate, but where lead acetate is used slightly higher than theory for arsenic oxide and slightly lower for lead oxide, indicating that probably some secondary reaction takes place during the process of manufacture, resulting in the formation of some compound other than lead arsenate, probably an acid lead arsenate. By referring to the analyses of the samples on the water-free basis, it appears that **18703, 19209, 19210, 19213** and **19643** are made from lead nitrate, the others from lead acetate. Formerly it was the practice to add glucose to increase the adhesive power of the arsenate, but it has been shown that it adheres almost as well without glucose as with it, and its use has been largely discontinued.

Allowing for the variations in process of manufacture, it would seem, however, that the content of arsenic oxid in the various commercial lead arsenates was conditioned more by the wetness of the material than anything else; the content of water in the samples analysed ranged from 33.65 to 58.44 per cent. A perfectly dry material has not been found advantageous, for while even in such a form it remains in suspension several times as long as the finest Paris green, it settles about three times as fast as when the arsenate is used in the form of a paste. On the other hand, the paste must not be too tenacious or it will be difficult to break up and distribute evenly throughout the spraying mixture. Colby† has found this objection to hold with Disparene. In making the water-soluble determinations it was observed that there were marked variations in the rate of settling even when the samples were in the dry and powdered condition. It is probable that the same peculiarity would have been noted in the samples in their original state, but as in most cases the

* U. S. Dept. of Agl., Bur. of Chem., Bull. 105, 168.

† California Expt. Station, Bull. 151.

whole sample had already been dried, verification of this supposition was impossible.

HOME-MADE LEAD ARSENATE.

It has frequently been recommended that farmers prepare their own lead arsenate as they need it. Colby* recommends the following formula: Dissolve 24 oz. of lead acetate or 20 oz. of lead nitrate in one gallon of cold water; also separately dissolve 10 oz. sodium arsenate in three quarts of water, both solutions to be made in wooden vessels. Pour the separate solutions into the spray tank containing from 100 to 150 gallons of water; a white precipitate of lead arsenate immediately forms. This preparation may be made several times stronger without the least danger of injury to the foliage. The freshly precipitated home-made arsenate seems to keep in suspension better than even the best commercial preparations.

COST OF LEAD ARSENATE.

As stated before, only one of the samples was bought in the open market; the prices have therefore not been affixed in any case. By correspondence with the manufacturers the Station received quotations as follows: In 100 lb. kegs, from 9.5 to 13 cents per lb.; in 5 to 20 lb. buckets, from 11 to 16 cents per lb.; and in 1 lb. cans from 11.5 to 17 cents per lb. The advantage of purchasing in quantity is apparent.

ITS ADVANTAGES.

Lead arsenate is very effective against leaf-eating insects. Its chief advantages over Paris green are its greater adhesive power and its harmlessness to the foliage. A single treatment of lead arsenate will adhere to the foliage for a period during which two or three sprayings with Paris green would be necessary to secure the same effect. The insolubility of its arsenic makes possible the use of large quantities without danger even in inexperienced hands. From the standpoint of effectiveness lead arsenate, although containing but from one-third to one-fourth as much actual arsenic as Paris green, is nearly as economical as the latter poison when sold at the same price. Purchased at the wholesale quotations noted elsewhere, and considering the duration and safety of its action, it is actually somewhat cheaper than Paris

* Loc. cit.

green. Furthermore, its greater power of suspension makes it more easily used and insures a more uniform distribution of the poison over the plant.

PARIS GREEN.

There is no law in this State regulating the sale of Paris green, but where a state inspection is in effect the requirements are generally very similar to those in the New Jersey law,* section 3 of which reads:

"Paris green, or any product analogous to it, when sold, offered or exposed for sale as such, in this State, shall comply with the following requirements:

"First. It shall contain arsenic, in combination with copper, equivalent to not less than fifty per centum arsenious oxide.

"Second. It shall not contain arsenic in water-soluble forms equivalent to more than three and one-half per centum of arsenious oxide."

Many analyses of Paris green have been made by the various Experiment Stations, showing the green to be of variable composition. These variations are chiefly due to different methods of manufacture or carelessness in carrying out the same. In many cases a large amount of the arsenic exists as free arsenious oxid, which may arise from intentional addition of white arsenic, as well as from careless manufacture. This is a serious adulteration, for white arsenic is a cheaper material, and its solubility in water renders its presence in anything but small quantities a source of much danger to foliage from scorching. Other adulterations have been detected, but the one just referred to is the most prevalent and most objectionable.

Paris green is essentially copper aceto-arsenite, and, if pure, should contain an equivalent of 58.65 per cent. arsenious oxide, 31.29 copper oxide and 10.06 acetic acid. The commercial article, however, usually contains small quantities of moisture and sand and varying amounts of sodium sulphate.

Twelve samples, representing eight manufacturers, were purchased from dealers by the Station sampling agent. A description of these follows:

19481. Made by A. B. Ansbacher & Co., New York. Sold by Lyon & Ewald, New London.

18662. Made by A. B. Ansbacher & Co., New York. Sold by the Sisson Drug Co., Hartford.

* New Jersey Expt. Station, Bull. 195.

18634. Made by E. J. Barry, New York. Sold by Odell's Pharmacy, New Britain.

18509. Made by E. J. Barry, New York. Sold by J. H. & W. E. Cone, Hartford.

18704. Made by James A. Blanchard, New York. Sold by F. S. Platt, New Haven.

19547. Made by Morris Hermann & Co., New York. Sold by D. B. Wilson Co., Waterbury.

18569. Made by Leggett & Bro., New York. Sold by Lockwood & Palmer, Stamford.

18508. Made by Leggett & Bro., New York. Sold by M. H. Mallett, New Milford.

18512. Made by I. Pfeiffer, New York. Sold by Frank M. West, Bridgeport.

18510. Made by C. T. Reynolds & Co., New York. Sold by H. K. Brainard, Thompsonville.

18511. Made by C. T. Reynolds & Co., New York. Sold by Danbury Hardware Co., Danbury.

18663. Made by The Sherwin-Williams Co., Newark, N. J. Sold by R. E. Page, Hartford.

ANALYSES OF PARIS GREEN.

Station No.	Manufacturer.	Cost of Package.	Weight of Package.		Arsenious Oxide. (As ₂ O ₃).			Copper Oxide. (CuO).	Arsenious Oxide combined with copper.
			Claimed.	Found.	Total.	Water-Soluble. 1 day.	Water-Soluble. 10 days.		
		cts.	oz.	oz.	%	%	%	%	%
19481	Ansbacher	13	* 4	3.6	57.92	1.46	2.92	28.76	53.78
18662	"	10	4	4.0	57.44	0.97	2.44	29.49	55.15
18634	Barry	35	*16	14.5	57.23	1.71	6.82	29.55	55.26
18509	"	18	* 8	8.0	56.62	2.44	6.82	29.01	54.25
18704	Blanchard	10	4	5.0	57.03	2.44	7.31	28.14	52.62
19547	Hermann	18	* 8	7.6	56.20	2.44	4.87	28.54	53.37
18569	Leggett	10	* 4	3.6	60.61	5.85	10.72	27.15	50.77
18508	"	20	8	7.3	56.83	2.92	8.77	29.34	54.87
18512	Pfeiffer	20	8	8.0	56.71	1.46	4.38	30.27	56.60
18510	Reynolds	28	*16	15.4	60.83	1.95	6.32	26.56	49.63
18511	"	10	* 4	4.0	61.19	2.44	9.74	27.15	50.77
18663	Sherwin-Williams	10	4	3.6	56.56	1.46	2.92	29.88	55.88

* Weight printed on label; in all other cases the weight is assumed from the size of package and price asked.

All the samples were carefully weighed with and without the container; one sample was overweight, four equalled the weight claimed, and seven were short weight. These shortages varied from 4 to 10 per cent., not large in any case, but indicating that the manufacturers' claimed weight is intended to include the weight of the container as well as the green itself, a practice without justification.

CHEMICAL ANALYSIS.

Total Arsenious Oxide. All the samples contained satisfactory amounts of total arsenious oxide, varying from 56.20 to 61.19 per cent. with an average of 57.93 per cent.; this average is only slightly lower than the equivalent of arsenious oxide contained in pure copper aceto-arsenite. Judging, therefore, alone from the content of arsenious oxide, it would appear that the Paris green on the market in Connecticut is of high quality. A definite decision as to the purity of the green, however, cannot be reached without considering also the amount of water-soluble arsenic present.

Water-Soluble Arsenious Oxide. Free arsenious oxide is always soluble in water, and the combined arsenic is liable to be rendered soluble by prolonged treatment. Two methods for determining soluble arsenious oxide have been adopted provisionally by the Association of Official Agricultural Chemists, in one of which sodium acetate is used as the solvent, while in the other the green is treated with water for ten days. Investigations with these methods have shown that the sodium acetate method gives more closely the true percentage of free arsenious oxide, while the water-extraction method gives in addition some arsenic caused by the decomposition of the green by water. From a practical standpoint the portion of the green that is so loosely combined would in all likelihood soon break up and scorch the foliage quite as badly as would free arsenious oxide. The water-extraction method would seem, therefore, to indicate more accurately the probable effect of the green on foliage.

The provisional method of the A. O. A. C. requires treatment with water for ten days, but it has been pointed out that the usual practice among horticulturists is to mix the green with water not very long before they wish to use it. For this reason certain Stations, for instance New York, California and New Jersey,

have adopted a one-day extraction period, which it is believed gives results more in harmony with actual practice. This Station has likewise adopted this method in the present work, and analyses by both the one-day and ten-day extractions are given in the table for comparison. The analyses clearly show that, if the ten-day method is to prevail as a standard, but three of the samples would fall within the usual legal limit of three and one-half to four per cent. of soluble arsenious oxide. With the one-day method, but one sample, **18569**, contains an excessive amount, 5.85 per cent. This sample varies greatly in composition from a duplicate sample from the same manufacturer, and under the microscope clearly shows the presence of white arsenic. The use of this sample would be exceedingly dangerous to foliage.

Copper Oxide. The amount of cupric oxide found in the samples varied from 26.56 to 30.27 per cent., with an average of 28.65 per cent. In pure copper aceto-arsenite the ratio of arsenious oxide to copper oxide is as 1.87 is to 1.00. This ratio is of value in assisting to determine whether white arsenic has been used to fortify the green, for arsenious oxide cannot be added without increasing the ratio. In the samples analysed, the ratio varied from 1.87 to 2.29; the high ratio shown in sample **18569** gives additional evidence of the presence of considerable quantities of white arsenic. The amount of arsenious oxide in combination with copper varied from 49.63 to 55.88 per cent., with one exception above the usual legal requirement of 50 per cent. In three of the samples the amount of arsenious oxide is more than 2.20 times that of the copper oxide, and the natural inference is that either arsenic has been added purposely or that the material has been carelessly manufactured.

A comparison of the water-soluble arsenic in Paris green and lead acetate emphasizes one of the chief advantages gained by using the latter insecticide. In lead arsenate from 0.22 to 1.31 per cent. was soluble in ten days, while in Paris green the solubility ranged from 2.44 to 10.72 per cent.

II. DIRECTIONS FOR THE USE OF LEAD ARSENATE AND PARIS GREEN AS INSECTICIDES.

By W. E. BRITTON, *Entomologist*.

Lead arsenate as an insecticide was first used in the work of the Gypsy Moth Commission in Massachusetts in the early nineties and it has since been employed in controlling nearly all of the leaf-eating insects, and has proved to be a valuable addition to our list of available arsenical poisons. When devoured by insects it is somewhat slower in its action than Paris green, and should therefore be applied earlier, before much damage has been done to the plants. On account of the excellent adhesive qualities of lead arsenate, it remains upon the foliage for a long time, while Paris green soon washes off if rains are frequent. Lead arsenate is gradually replacing Paris green as an arsenical insecticide, and especially during the past season the high price of the latter has induced many farmers and fruit growers to use lead arsenate. Paris green has been used to destroy leaf-eating insects ever since the Colorado potato beetle reached the Atlantic States. It is therefore the old standard remedy, and in many places is the only arsenical insecticide that can be purchased at the stores.

FORMULA FOR LEAD ARSENATE.

As lead arsenate is sold in paste form, and even when calculated as water-free contains less arsenic than Paris green, it is necessary to use a larger quantity by weight of the commercial article to gain the desired end in spraying work. Lead arsenate can be used only in liquid form to be sprayed upon the foliage, and the usual formula is as follows:

Lead arsenate.....	3 lbs.
Water	50 gallons.

For sawfly larvae and some other insects that are easy to kill, one pound in fifty gallons may suffice, and in spraying to kill gypsy caterpillars five pounds in fifty gallons are the proportions considered the most effective. In spraying for elm leaf beetle larvae the poison should be directed against the under sides of

the leaves. The amount of lead arsenate may be increased greatly without danger of injuring the foliage, and lime should not be added. Lead arsenate can be used in connection with Bordeaux mixture, though it is thought to be slightly less effective as an insecticide when used in this way.*

FORMULA FOR PARIS GREEN.

Paris green is put up in powder form and can be applied either dry or as a liquid. On account of the soluble acid which it contains (see page 9 of this bulletin) there is always danger of "burning" the foliage unless some alkali is used with the poison. For this purpose lime is usually recommended, and the adhesiveness of the mixture is greatly improved by the lime. About three pounds of lime should be used for each pound of Paris green. If to be applied dry in a duster or powder gun, Paris green should be mixed thoroughly with air-slaked lime or land plaster in the following proportions:

Paris green	1 pound.
Air-slaked lime	100 pounds.

For use as a spray Paris green may be prepared as follows:

Paris green	1 pound.
Fresh quicklime	3 pounds.
Water	100 gallons.

In most orchards and potato fields Paris green is used in connection with Bordeaux mixture, and as this contains an excess of lime, no more lime is added.

* Tests made at this Station show that the presence of the Bordeaux mixture renders the lead arsenate perfectly insoluble. This perhaps may account for its lessened poisonous effect on insects.

M.F. 5111
2 OCT. 1923
ENTOM.

CONNECTICUT
AGRICULTURAL EXPERIMENT STATION
NEW HAVEN, CONN.

BULLETIN 184, DECEMBER, 1914.

SPRAY TREATMENT, ETC., for ORCHARDS.



CONTENTS.

	Page		Page
Officers and Staff	2	Summer Spraying	6
Spray Treatment, etc., for		Apple	6
Orchards	3	Pear	8
Winter Treatment	3	Peach	8
Pruning as a Control Measure	3	Plum	8
Winter Spraying	4	Cherry	9
What to Use	5	Quince	9
Lime-Sulphur Mixtures . .	5	Directions for Making Spray	
Miscible Oils	6	Mixtures	10
Lime-Sulphur versus Misci-		Cautions	11
ble Oils	6		

The Bulletins of this Station are mailed free to citizens of Connecticut who apply for them, and to others so far as the editions permit.

CONNECTICUT AGRICULTURAL EXPERIMENT STATION.

OFFICERS AND STAFF.

BOARD OF CONTROL.

His Excellency, Simeon E. Baldwin, *ex-officio*, *President*.

Prof. H. W. Conn, *Vice President* Middletown
George A. Hopson, *Secretary* Wallingford
E. H. Jenkins, *Director and Treasurer* New Haven
Joseph W. Alsop Avon
Wilson H. Lee Orange
Frank H. Stadtmueller Elmwood
James H. Webb Hamden

Administration. E. H. JENKINS, PH.D., *Director and Treasurer*.
MISS V. E. COLE, *Librarian and Stenographer*.
MISS L. M. BRAUTLECHT, *Bookkeeper and Stenographer*.
WILLIAM VEITCH, *In charge of Buildings and Grounds*.

Chemistry.

Analytical Laboratory. JOHN PHILLIPS STREET, M. S., *Chemist in Charge*.
E. MONROE BAILEY, PH.D., C. B. MORISON, B.S.,
C. E. SHEPARD, G. L. DAVIS, *Assistants*.
HUGO LANGE, *Laboratory Helper*.
V. L. CHURCHILL, *Sampling Agent*.
MISS E. B. WHITTLESEY, *Stenographer*.

Proteid Research.

T. B. OSBORNE, PH.D., *Chemist in Charge*.
MISS E. L. FERRY, M.S., *Assistant*.

Botany.

G. P. CLINTON, SC.D., *Botanist*.
E. M. STODDARD, B.S., *Assistant Botanist*.
MISS E. B. WHITTLESEY, *Herbarium Assistant*.
G. E. GRAHAM, *General Assistant*.

Entomology.

W. E. BRITTON, PH.D., *Entomologist; State Entomologist*.
B. H. WALDEN, B.AGR., *First Assistant*.
Q. S. LOWRY, B.Sc., I. W. DAVIS, B.Sc.,
M. P. ZAPPE, B.S. *Assistants*.
MISS F. M. VALENTINE, *Stenographer*.

Forestry.

WALTER O. FILLEY, *Forester; also State Forester
and State Forest Fire Warden*.
A. E. MOSS, M. F., *Assistant Station Forester*.
MISS E. L. AVERY, *Stenographer*.

Plant Breeding.

H. K. HAYES, M.S., *Plant Breeder*.
C. D. HUBBELL, *Assistant*.

Vegetable Growing.

HOWARD F. HUBER, B.S.

SPRAY TREATMENT, ETC., FOR ORCHARDS.

By W. E. BRITTON, *Entomologist*, and

G. P. CLINTON, *Botanist*.

This bulletin has been prepared to meet a constant and growing demand for information regarding the general spraying of orchards in Connecticut. More specific and detailed accounts of the various insect and fungous pests of orchards may be found in the Spray Calendar and in the reports of this Station, especially those of the Entomologist, the Botanist, and in "Tests of Summer Sprays on Apples and Peaches", Reports 1910, page 583, and 1911, page 347. Some of these are out of print and can no longer be supplied.

If the orchardist finds troubles not readily recognized by means of the publications just mentioned, or if they are new to him, he should send specimens to the Station for identification and for advice about treatment. All such specimens should be placed in a strong paper, wood or metal box, so as not to be crushed in the mails. All communications are answered when the sender's name and address accompany specimens.

WINTER TREATMENT.

PRUNING AS A CONTROL MEASURE.

In most peach and apple orchards it is the usual practice to prune before spraying the dormant trees, especially before the March spraying with lime-sulphur or with miscible oil. All surplus wood may then be taken out, thus leaving less bark surface to be covered with the liquid. If the trees are attacked by San José Scale or any other kind of scale insect, the worst infested branches should be removed. All branches showing injury from the attack should be headed back in order to get a stronger growth from fewer buds.

Winter pruning is even more essential for fungous troubles than for insects. Of course one of the chief reasons for pruning is to take out unnecessary and interfering branches and shape up the tree, with resulting improved dry air drainage whereby infection by fungi is lessened, but even more

important is the removal of dead limbs and twigs and those showing diseased areas and cankers in the bark, as all these are frequently the carriers of the winter stage of injurious fungi. When it is not advisable to remove the cankered branch or trunk, the infected area should be carefully removed by cutting clear to the healthy bark and scraping out all the intermediary tissues. These scraped areas and the cut ends of the larger branches should be painted over when dry with white lead or coal tar.

After this pruning has been done the tree should be thoroughly coated with spray. It is a good practice to burn all diseased or infected branches which have been cut from the trees.

For the blight on pear, also on apple and quince when they are seriously affected by this bacterial disease, winter pruning is especially desirable, since the re-inoculation of the germs in the freshly cut surfaces is then much less likely than during the growing season. Even in winter, however, it is best to cut off the branches some distance below the diseased parts and wipe the pruning tool frequently with a cloth moistened in carbolic acid or corrosive sublimate solution, to kill any accidentally attached germs.

For cherries and plums attacked by black knot, pruning in late fall or in winter before the winter spore stage starts to germinate is likewise desirable. Cutting *out* the knots has not been found very satisfactory, so all infected branches should be cut *off* several inches below any signs of the knot. When possible, it is best to commence this pruning with the young trees as it sometimes requires severe treatment to remove all knots. This should be kept up each year until the knots fail to reappear. In case the tree is severely cut back, additional pruning is needed from time to time to re-shape the tree, remove water sprouts, etc. The knots should be carefully gathered up and burned before spring. Watch should be kept of wild cherry and plum trees in the neighborhood, lest they serve as a means of infection.

WINTER SPRAYING.

Spraying of orchard trees, when dormant, was first made necessary in Connecticut from ten to fifteen years ago by the

prevalence of the San José Scale, which ruined many peach orchards and seriously damaged apple orchards. Winter spraying is practiced for the purpose of destroying insects rather than fungi, though one fungus, the peach leaf curl, may also be controlled by this treatment.

Besides the San José Scale, certain other pests, such as the leaf blister mite on pear and apple, the clover mite which may be found on any kind of trees, the pear *Psylla* on pear, the green apple aphid and the rosy apple aphid on apple, may all be wholly or partially controlled by the winter treatment.

For most of the insect troubles mentioned above, the trees may be sprayed as soon as the leaves drop in November, or just before the buds open in April. The fall application will probably kill more San José scales than the spring application, because they are not then protected by their winter covering and often the naked young may be seen crawling about until December 1st. Where trees are badly infested with San José Scale, it is usually advisable to spray twice, once in November and again in April, as the second will often cover parts of the tree that were missed by the first treatment.

For peach leaf curl, however, the early spring treatment is advisable, and some newly-hatched aphids will then be killed which were not present on the trees at the time of the November application.

WHAT TO USE.

Lime-Sulphur Mixtures.

The best all-round spray for peach, plum and all young and smooth-barked trees is the lime-sulphur mixture. In some of the larger orchards this is made on the place which, no doubt, is the cheapest and best way, if the size of the orchard warrants the outlay for the plant. In most cases, however, the owner will prefer to purchase his lime-sulphur, and he can buy the commercial liquid lime-sulphur in any desired quantity, ready to dilute and apply, and be fairly certain of procuring a good article. This commercial lime-sulphur should test about 33°B and it should be diluted at the rate of one part in nine parts of water.

There are now on the market several dry lime-sulphur mix-

tures which claim a great saving in freight by not shipping the water. Some of these are sulphides of basic elements other than lime, and they will probably prove good insecticides and possibly fungicides, without causing injury to the trees, but they are still more or less in the experimental stage.

Miscible Oils.

If one has large and old apple trees with rough bark and badly infested with San José Scale, he may be able to rid them of the scale quicker by spraying with one of the so-called soluble or miscible oils, such as "Scalecide", "Carboleine" or "Jarvis Compound" than with lime-sulphur, because the oils have a greater penetrating power and will go into the cracks and crevices. It will also moisten the pubescent twigs and "crawl" around them. These oils should be diluted at the rate of one part to fifteen parts of water.

Lime-Sulphur versus Miscible Oils.

The oils are not so good fungicides as is lime-sulphur and, when they do not mix freely with water, are liable to cause injury and should not be used. There is no danger of injuring dormant trees with the lime-sulphur mixtures. Moreover newly hatched scales will establish themselves readily on bark which was sprayed with oil preparations in the spring, but they do this very sparingly on bark treated with lime-sulphur; consequently, if any are present they are found on the new growth—twigs, leaves, or fruit.

At the Station farm, Mt. Carmel, in the old and neglected orchard of about fifty trees, some of which were badly infested, the San José Scale has been controlled satisfactorily for four years by the use of lime-sulphur,—no miscible oil ever having been used. The trees are now nearly free from scale, but for two years they were given both fall and spring treatments.

SUMMER SPRAYING.

APPLE.

In the average apple orchard only two summer spray treatments need be given, the first soon after the blossoms fall and the second from three to four weeks later, the spray being lead

arsenate (3 lbs. of the paste, or $1\frac{1}{2}$ lbs. dry, in 50 gallons of water) to kill the codling moth or apple worm which is always present; and usually combined with some fungicide such as commercial L. & S. ($1\frac{1}{2}$ gallons). The beginner should follow this simple treatment until he learns what special troubles he needs to control, and unless somewhat familiar with spraying practices, he may be confused by the more complicated combination formulas and directions for controlling the various pests. He should begin at the bottom and "work up".

For the orchardist more experienced in spraying and identifying insect and fungous pests, we recommend the following three treatments, or such as he may need, for controlling the particular enemies of his orchard:

(1). In certain localities and in certain seasons, canker worms, bud moths, tent-caterpillars and brown-tail moths may do great damage. In case any or all of these are present the worms feed on the unfolding leaves, and a spray of lead arsenate should be given before the blossom buds open, though not until there is considerable expanded leaf-surface to hold the poison. If scab and rust are prevalent, a fungicide, preferably Bordeaux mixture, 4-4-50, should be added to the poison for this treatment, or if the insects mentioned above are not troublesome, it may be used alone.

(2). After the blossoms fall the experienced orchardist will use a fungicide, preferably dilute lime-sulphur, $1\frac{1}{2}$ gallons in 50 gallons of water. Where there is little danger of russeting the fruit, weak Bordeaux mixture (which is a better fungicide) 1-4-50, may be used instead of lime-sulphur. Lead arsenate should be added in either case. If there is a prospect of considerable damage from aphids, leaf-hoppers, scale-insects, red-bugs, or pear *Psylla*, a 40 per cent. nicotine solution, $\frac{1}{2}$ pint per barrel, may be added to the combination without injury to the foliage and without impairing the insecticidal or fungicidal properties of the mixture.

(3). The combined fungicide-insecticides just mentioned may be used for the June or third spraying but the nicotine may not then be necessary. This third spraying takes care of the second brood of codling moth, late chewing insects, etc., also the sooty blotch, late scab and various fruit specks and rot fungi.

PEAR.

As a rule pears do not require so much summer spraying as apples and the treatments are given for specific troubles. It may be advisable to apply poison for codling moth, pear slug and other leaf-eating insects, and a fungicide, preferably Bordeaux, to control leaf blight and scab. Occasionally nicotine may be needed to control plant bugs or the pear Psylla. The applications should be made at the same three periods as for apples; namely, on the unfolding leaves before the blossoms open, just after the petals fall, and about three weeks later.

In case pear blight is serious despite the winter pruning, summer pruning, with especial care not to spread infection by means of the pruning tools, is sometimes desirable.

PEACH.

Peach foliage seldom needs to be sprayed with poison. In Connecticut orchards the peach sawfly has caused partial defoliation and in such cases one spraying with lead arsenate (2 lbs. paste in 50 gallons water) should be given about the middle of June. This may be added to the self-boiled lime-sulphur, which is the safest fungicide for controlling scab and brown rot.

Scab can usually be controlled by two treatments,—one on the young fruit about the middle of May, and another the middle of June, while rot is often largely prevented by two treatments about the middle of June and July. Three treatments, about the middle of each of these months, will take care of both troubles fairly well. Summer spraying is most advisable in case of such badly rotting varieties as Champion, etc., or when Elberta, etc., scab badly. It has hardly come into general practice in this state, but deserves more attention than has yet been given it. Atomic Sulphur has proved as satisfactory in our experiments as the self-boiled lime-sulphur in controlling these two fungi.

PLUM.

Plum orchards may need to be sprayed occasionally with poison to prevent damage from canker worms or other leaf-eating insects. Some writers recommend this treatment against

curculio, but probably the jarring method of control will usually be found more satisfactory.

For the control of brown rot the fruit should be thinned, and after harvest all mummies should be gathered and destroyed. While spraying is not entirely satisfactory, largely because the spray does not adhere readily to the smooth fruit, it may be desirable in certain cases. The first treatment should be made with self-boiled lime-sulphur on the fruit when about half grown, and be followed by a second, third, and possibly fourth spraying in case of late ripening varieties, at intervals of ten to fourteen days. The last spraying should be made about seven to ten days before picking, and can be made with commercial lime-sulphur, 1-150, if there is any danger of sediment on the fruit interfering with its sale. In case of leaf anthracnose, the spraying should be started earlier. *See Cherry.*

CHERRY.

Rarely is it necessary to spray cherries except for the control of brown rot on the sweet varieties, and for this purpose the self-boiled lime-sulphur should be used, the same as directed for plum.

In case the leaf spot "anthracnose" is troublesome, the spraying should be made earlier than for brown rot, the first application being made on the young leaves just after the petals fall, followed by one or two others at intervals of ten to fourteen days.

Occasionally there may be damage from the pear or cherry slug, in which case a weak lead arsenate mixture (say 2 lbs. in 50 gallons) may be applied. Unless the insects are present, however, it may well be omitted.

QUINCE.

Quince trees, like apples, should be sprayed with lead arsenate and a fungicide, preferably Bordeaux mixture. Three treatments, as for scab of apple and pear, are usually desirable. These help to control rust, black rot, leaf blight, and such chewing insects as are present. Summer pruning for the bacterial blight may be desirable in some cases.

DIRECTIONS FOR MAKING SPRAY MIXTURES.

Commercial Lime-Sulphur. Any of the commercial lime-sulphur mixtures on the market testing about 33° B. may be used for spraying fruit trees. For winter treatment these are usually diluted with one part of the mixture to 9 parts of water. For summer treatment the dilution is usually 1¼ to 1½ gallons to 50 gallons water.

Self-Boiled Lime-Sulphur. This is a home-made mixture prepared as follows: Eight pounds of fresh lime are started slaking in a barrel with a little water (warm water preferably in cool weather), and when the mass has begun to heat, eight pounds of sulphur flour are quickly sifted in and thoroughly stirred with the slaking lime. This, at the consistency of a rather thick paste, is allowed to heat for fifteen minutes from the time the sulphur is added, when it is cooled down with additional water. The mixture is stirred and strained into the spray barrel, to remove the coarser sediment, and diluted to the fifty gallons.

Usually three barrel lots can be made at a time in an ordinary barrel by using three times the amount indicated above. This amount furnishes more heat and makes a little better mixture than when made up in single barrel lots. A third of the amount is then used with a barrel of water.

Bordeaux Mixture. Four pounds of copper sulphate are dissolved in hot water or by suspending the crystals in a coarse bag in a half barrel of water. Four pounds of fresh lime are slaked in a small amount of water, and then strained into the spray barrel about half filled with water. To this is then added the half barrel of dilute copper sulphate.

When several barrels are needed, stock solutions can be made up as follows: The copper sulphate is dissolved in a barrel at the rate of one pound to one gallon of water, and the lime, after slaking, is diluted so that it also contains one pound per gallon of water. Then, when needed, four gallons of the lime water, after stirring thoroughly, are strained into the spray barrel, this half filled with water, and four gallons of the copper solution, further diluted to make about half a barrel, are poured into this.

Lead Arsenate. This poison is manufactured in both paste and powder form. The paste form is generally preferred for orchard work, but it dries and becomes lumpy if kept from one year until the next. It also corrodes metal containers. The paste contains fifty per cent. water and should be used in the proportions of 3 lbs. in 50 gallons of water. It is best to first mix it thoroughly with a small amount of water before putting into the spray tank.

Dry or powdered lead arsenate will keep indefinitely in a dry place. In spraying, use just half as much as of the paste form, or $1\frac{1}{2}$ lbs. in 50 gallons of water. The dry lead arsenate may be thrown into the spray tank after it has been filled with liquid, and it will be readily moistened and distributed.

Both paste and powdered lead arsenate may be used in connection with lime-sulphur, Bordeaux mixture, or nicotine solution and larger quantities of arsenate may be used if desired.

Nicotine Solutions. Several of these are now sold containing forty per cent. or more of nicotine, usually in the form of sulphate. For most kinds of aphids one-half pint to a barrel of water is sufficient, but the amount may be much increased or doubled without danger of causing injury. Nicotine solutions may be safely used in combination with lead arsenate, Bordeaux mixture, or lime-sulphur; with any one or with all of them.

Miscible Oils. Several brands are now on the market, and for dormant spraying each should be diluted at the rate of one part in 15 parts water. The contents of each original package should be thoroughly mixed or shaken before attempting to dilute any portion of it. As a rule, it is unnecessary and inadvisable to mix miscible oils with other spray materials. Such oils are chiefly used on dormant trees.

CAUTIONS.

Before beginning to spray, know what you are spraying for. If you have troubles which you cannot identify, send specimens to the Station and get information and advice.

Never spray any fruit tree while in bloom. It kills your best friends, the honey bees, which pollinate the flowers and

help to increase the yield of fruit. The spray will also injure the delicate floral organs, so that fruit will not set.

Be careful about using any kind of spray not advocated here, especially on peach and Japan plum foliage, which are especially susceptible to spray injury.

If miscible oils do not mix readily and thoroughly with water on diluting, they should be discarded, as there is danger of injuring the trees.

